Asian Journal of Medical Radiological Research Original Article

Determination of Hydronephrosis Causes In Pediatric Patients Using CT

O'hood Al-Hussein Mohammed[1], Ikhlas Abdelaziz Hassan[*1], Mohamed Ahmed Ali[1], Hussein Ahmed Hassan[1]

[1]College of Medical Radiologic Science, Sudan University of Science and Technology . P.O.Box 1908, Khartoum, Sudan

Abstract

The objectives of this study were to evaluate the accuracy of computerized tomography urography (CTU) in diagnosing hydronephrosis in pediatric Patient (less than 15 years), minimize the radiation dose , examination cost , and time to reach the final diagnoses. This study carried out in two hospitals: Fedail hospital and Ibn-Alhaytham Diagnostic Center, during the period from July 2012 to January 2013. Siemens somatom sensation 16 slice helical CT scan apparatus was used. Abdomen routine protocol was performed with or without administration contrast medium. A total of 63 patients their ages are (1-14 years) with hydronephrosis . CTU detected the underlying pathology of hydronephrosis in 59 patients (93.7%). CT has become superior modality for diagnosing the underlying pathology of hydronephrosis , and concluded to that CTU is the best protocol for demonstration the underlying pathology of hydronephrosis than other modalities as ultrasound (U/S) and intravenous urography (IVU).The objectives of this study are to evaluate the ability of CT in the diagnosing of the urinary system diseases of pediatric in order to assesses CT in cases of hydronephrosis in pediatric Patient (less than 15 years).

Key Words: Computerized Tomography Urography(CTU), Hydronephrosis, Protocol, Pediatric

INTRODUCTION

Computed Tomography (CT) is a nondestructive technique for visualizing interior features within solid objects, for obtaining digital information on their 3-D geometries and properties and a method of acquiring and reconstructing.[1] In comparison with conventional radiographs CT images are free of superimposing tissue and are capable of much higher contrast due to the elimination of scatter. Computerized tomography urography CTU demonstrates more soft tissue information than IVU in the patients with urinary tract tumors. CTU may be an alternative modality for patients with deterioration of impairment renal function or allergic history of contrast media.Intravenous urography IVU has long been the major and first line modality in evaluating general urinary tract abnormalities, the imaging findings are prone to be affected by artifacts (bowel gas or bowel contents), and poor or non opacified urinary tract (due to impairment renal function).[2] For radiolucent stones IVU are also limited. The fore mentioned conditions are in prejudice instantly and correctly diagnosing urinary tract abnormalities. These situation not only for the clinician to order extra examination for further evaluation urinary tract disorders, but the final diagnosis and proper management for patient with acute clinical symptoms will also be delayed. Because of the limitation incorrectly diagnosing urinary tract abnormalities by IVU, a more accurate and rapid substitute modality for IVU is warranted. With improvement in examination techniques of CT, helical CT scan has become an alternative modality in evaluating urinary tract abnormalities, especially for Urolithiasis.[3] The good imaging resolution and rapid examination time of helical CT significantly improves examination course compared to that of IVU. But the axial images of CT may cause some interpretation difficulties for clinicians who are familiar to analyze to coronal images for IVU. Reformatted 3-dimention (3D) CT urography from thin-cut axial helical CT scan can create a coronal imaging which is like the imaging of IVU. Three–dimensional CT urography is not only easily interpreted by the clinicians who are unfamiliar with axial CT image, but it also improves the accuracy in diagnosing urinary tract abnormalities.[2] Computed tomography CT is widely used in radiological evaluation of the kidneys and urinary collecting system, including renal masses, infection, truma, and urinary calculi as a result, CT is commonly used instead of intravenous urography IVU for evaluation of these clinical problems. The technical advance that enabled widespread use of CT for imaging urinary calculi was the introduction of slip-ring technology (spiral CT) in 1990 that for the first time permitted imaging of abdomen in a single breath hold, free of respiratory misregistration, despite such advances, acknowledge, been satisfactory developed, and initial image–based evaluation of underlying pathology of the hydronephrosis in many center still relies on IVU. The primary reasons that CT has not replaced IVU for evaluation of the urothelium are that CT has lower spatial resolution and that it is difficult to acquire asset of images in which the intra renal collecting system (IRCs) and the ureters are completely opacified. With multi detector row CT, multiple channel of data are aquired simultaneously, allowing thinly collimated images to be obtained through the entire abdomen in asingle breath hold result in near-isotrpic voxel and improved spatial resolution in non transverse plane during the excretory phase, the entire collecting system and ureter can be imaged with one acquisition. As with conventional IVU, visualizing the IRCS and ureter depends on opacification and distention. A fundamental problem in CT urography (or any imaging technique for imaging the entire collecting system and ureter) is that, because of peristalsis, it is difficult to obtain a single image on which all segment are opacified and distended. The purpose of my study to evaluate several protocols for depiction of the underlying pathology of hydronephrosis with multi detector row CT urography.[2] Imaging evaluation of patients with acute flank pain is

Address for correspondence*

Dr. Ikhals Abdelaziz

Sudan University of Science and TechnologyP.O.Box 1908, Khartoum, Sudan Tel: 00249121330207 Fax: 00249 183 785215 E_mail: Ikhlas_Abdelaziz@yahoo.com

traditionally based on intravenous urography IVU as the standard screening tool for detecting urinary calculi. IVU require IV contrast medium, with its associated potential risk.[4] In addition, the length of this examination may preclude rapid evaluation of patient in an emergency setting .These considerations have led to the use of other techniques, such as the combination of plain abdominal radiography and ultra sound and more recently unenhanced helical CT. Plain radiographs are not sensitive to non-radio-opaque calculi or to non-calculous obstruction. Plain radiography also lacks specificity, as phleboliths, which are common pelvic calcifications, are not always readily differentiated from urinary tract calculi. The advantages of CT over IVU are well documented and include shorter examination time, avoidance of intravenous contrast medium, greater sensitivity for stone detection and increased detection of abnormalities unrelated to ureteral stones. However, radiation dose is high.[4] Trans abdominal Ultrasound has the advantage of being universally available, does not expose the patient to radiation, requires no IV contrast medium and is independent of kidney function; U/S is therefore attractive as the modality of choice for the initial evaluation of urinary symptoms. This prospective study compared the accuracy of spiral CT with U/S in the evaluation of patient with acute flank pain. CT scanning for underlying pathology of hydronephrosis, has an important role in the evaluation of hydronephrosis and hydroureter, retroperitoneal processes causing extrinsic obstruction of the ureter and bladder are evaluated best on CT scan; unenhanced helical CT scanning is currently the imaging modality of choice to assess for a possible calculus. It provides 97% sensitivity, 96% specificity, and 97% over all accuracy in diagnosis of stones. Many stones that were once considered radiolucent (eg, uric acid stones) are readily apparent on CT scan. One exception is stones that are composed of HIV protease inhibitor (indinavir), which are not visualized by CT.[4] The benefit of CTU is that viewing a CT scan, an experienced radiologist can diagnose many causes of abdominal pain with very high accuracy, enabling faster treatment and often eliminating the need for additional, more invasive diagnostic procedure. Unlike other imaging methods, CT scanning offers detailed views of many types of tissue, including the lungs, bones, soft tissues and blood vessels. CT scanning is painless, non-invasive and accurate. CT examinations are fast and simple. For example, in emergency cases, they can reveal internal injuries and bleeding quickly enough to help save lives. Diagnosing made with the assistance of CT may eliminate the need for invasive exploratory surgery and surgical biopsy. CT scanning can identify both normal and abnormal structures, making it a useful tool to guide radiotherapy, needle biopsies and other minimally invasive procedure. CT has been shown to be a cost-effective imaging tool for a wide range of clinical problem.[5]

CT scanning is not the primary method of examining the inside or lumen of the hollow organs, such as the stomach and bowel, with the exception of virtual colonoscopy, which can be used to evaluate the lumen of the large bowel.[5] Computerized Tomography Urography CTU demonstrate more soft tissue information than IVU in patient with urinary tract tumor CTU is an alternative modality for patient with deterioration of impairment renal function or allergic history of contrast media.[3] Hydronephrosis refers to dilatation of renal pelvis and calyces with accompanying atrophy of the parenchyma obstruction to the outflow of urine the obstruction may be sudden or insidious and may occur at any level of urinary tract from the urethra to the renal pelvis. Hydronephrosis caused by either congenital causes like atresia of urethra, value formation in either ureter or urethra or acquired causes like calculi, necrotic papillae, tumor and inflammation in urinary tract. Bilateral Hydronephrosis as well as unilateral Hydronephrosis when the other kidney is already damaged or absent lead to renal failure.[6] Unilateral Hydronephrosis may remain. Hydronephrosis occurs bilateral when obstruction is below the level of the ureter or unilateral when the blockage is at the ureter or above and may be completely silent for along time of period unless the other kidney is for some reason none functioning. Often the enlarged kidney is discovered on routine physical examination.[6] Removal of obstruction within a few weeks usually permits full return of function.

The most common causes are benign prostatic hyperplasia, urethral stricture and calculi less common causes include stricture or stenosis of the ureter or bladder outlet, congenital abnormalities, abdominal tumor, blood clot, and neurogenic bladder.[2] If obstruction is in the urethra or bladder, hydronephrosis is usually bilateral; if obstruction is in a ureter, its usually unilateral. Obstruction distal to the bladder causes the bladder to dilate and act as a buffer zone, delaying hydronephrosis. Total obstruction of urine flow with dilation of the collecting system ultimately causes complete cortical atrophy and cessation of glomerular filtration. Hydronephrosis may or may not cause any symptoms. If symptom occur, they may include, pain in the back, waist, lower abdomen, or groin, persistent pain with urination or urinary frequency (from urinary tract infection), increased urge to urinate or urinary incontinence, dribbling after urination, fever, nausea, vomiting, and unexplained itching.[6] The objectives of this study were to:(I) determine the accuracy of computerized tomography urography (CTU) in diagnosing hydronephrosis in pediatric Patient,(II) minimize the radiation dose , examination cost , and time to reach the final diagnoses.

MATERIALS AND METHODS

Materials used in this study are, CT scan apparatus, semens somatom sensation 16 and water salable none ionic contrast media (amanopaque). The patients sample consisted of 63 pediatric patients, 42 male and 21 female and their age ranged from (1 to 14years) with mean age of 7 years used in this study. All co-patients were informed and agreed that the information from their children exams will be used in this study

Machine used for the study

CT machines Siemens-somatom sensation 16 slice which Manufactured in 2003 was used. This machine was installed in 2006. The machine has 70 cm gantry Aperture with ability to tilt +/-30,rotation times: 0.5,0.75,1.0s,Max. Table load: 200kg, scan able range: 157cm, spiral imaging:- Real-time reconstruction: up to 6 slices/s,reconstructed slice width: 0.75, 1.0, 1.5, 2, 3, 4, 5, 6, 7, 8, 10mm, Scan time: max. 100s -Scan
length: max. 157cm. Tomogram: Scan time: 1.6 – 15.6s, Sequence:- Reconstructed slice width: 0.6, 0.75, 1, 1.5, 2, 3, 4.5, 5, 6, 9, 10, 12, 18mm,Scan cycle: 0.75 – 60.0s.

The methodology

The technique

The protocol used in siemnse16 for CTU called abdomen routine, kVp 120. Effective mAs 140 ,Slice collimation 1.5 mm ,Slice width 5.0 mm ,Rotation time 0.5 sec

Increment 5.0 mm and Pitch = 1

Contrast medium IV injection ,Start delay 4 – 30 sec with flow rate 2 ml/sec

Patient lies supine with arms over head on CT table (especial immobilization was made for the children to avoid motion artifact) scout image was aquired from diaphragmatic dome to symphsis pubis with field of view start from costophrenic angles to symphsis pubis

Slice thickness should not exceed 5mm pitch of .05 -1 ,Reconstruction in 2mm (better MPR) .Thin slab coronal (MIP MPR) images at the area of abnormality ,If IV contrast is needed the volume should be 1ml per kg.Scan delay 4 – 30sec

Data collection

Data collected from CT images findings by viewed the images and collected radiologist reports. Also reports from previous ultrasound and IVU used in collected the data. The data then represented in tables and graphs.

Data interpretation

The data result were collected from noticing hydronephrosis in the imaging and support the result by the radiologist report, samples of imaging .

Data analysis

Tables, graphs, and software (SPSS) were used to analyze the data.

Table (4. 1) demonstrates gender distribution

Male	Female
42	21

Table (4.2) demonstrates the percentage of underlying pathology by three modalities

NO	Underlying pathology	Modalities CT IVU 1 // 2 // 2	US 1 // 2	1
1	Stones	41 // -	30 // 11	25 // 11
2	Ureteric stricture	1 // -	- // 1	- // 1
3	UB CA	4 // -	4 // -	- // 4
4	Masses	7 // -	1 // 6	1 // 4
5	Renal tumor	5 // .	- // 5	
		2 // 3		
6	Diverticulum	1 // .	- // 1	- // 1

Table (4.3) demonstrates the percentage of underlying pathology of hydronephrosis in 63 patients by the three modalities

No	Moda lity	No of patient	1	2	P er centa ge %
1	C T	63	59	4	93.7
2	U S	63	35	28	56
3	I VU	51	27	24	53

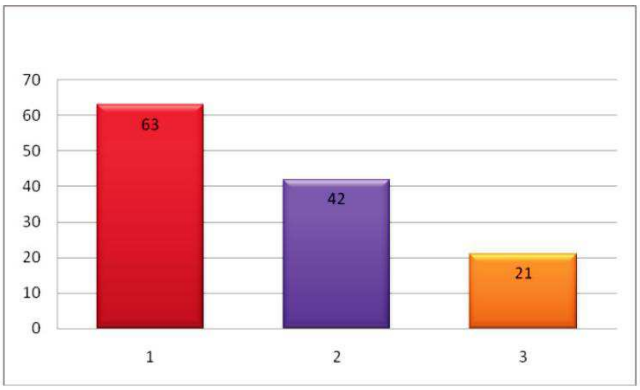

Fig (4.1) shows gender distribution

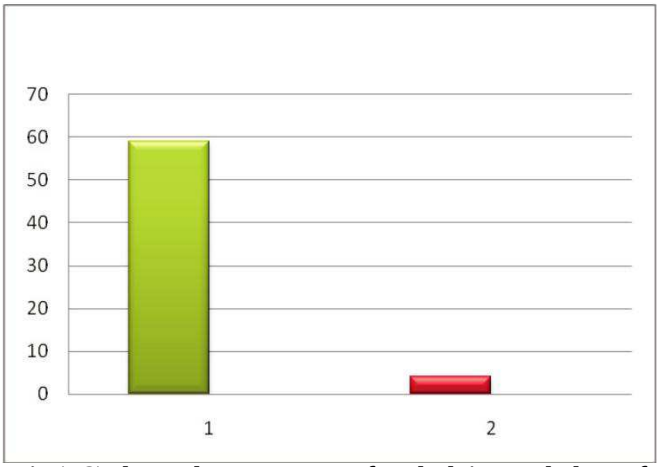

Fig (4.2) shows the percentage of underlying pathology of

RESULTS

This study carried out in two hospitals: Fedail hospital and Ibn-Alhaytham Diagnostic Center, during the period from July 2012 to January 2013 .16 slice helical CT scan apparatus was used. Abdomen routine protocol was performed with or without administration of contrast medium. A total of 63 patients their ages are (1-14 years) with hydronephrosis .The data was presented in tables and figures as follow:-

DISCUSSION

In 63 years old patients in this study ,41 patient were proven to have stones as the main underlying pathology of hydronephrosis, 7 cases of masses, ,4 cases of urinary bladder cancer, 4 cases of urinary tract tumor, one case distal ureteric neoplasm , one case of vesico ureteric diverticulum , and one case ureteric stricture. CT completely diagnosed the upper underlying pathology in these 59 cases of 63 cases (93.7%). In other 4 cases CT detected hydronephrosis but failed to delinate the cases or underlying pathology of it, these cases include, one case of distal ureteric legation during surgical operation lead to aggressively hydronephrosis , one case of urinary tract neoplasm, and tow cases of chronic inflammatory of urinary tract (biopsy shows granulomatous changes). All patients under went CTU, 21 cases were completely diagnosed with unenhansed CT-KUB and in 42 cases with enhanced CTU. CT gave hundred percentages for diagnosing all cases of the stones, tumor, UB CA, ureteric stricture, diverticulum, and detected the cases of the hydronephrosis and the site of obstruction in other four cases

without delineated the causes of the obstruction. All patients underwent ultrasound, it well diagnosed 35 cases of 63(56%) and detected hydronephrosis in other 28 cases without delineated the underlying pathology. In 41 cases of urinary tract stones U/S well diagnosed the underlying pathology in 30 cases (73%), it detected all cases urinary bladder carcinoma in 4 out of 4 cases (100%), and in 7 cases of masses U/S detected one case (17%) and completely failed to detect any of the following underlying pathology of hydronephrosis, ureteric stricture, vesico ureteric diverticulum, urinary tract tumor. distal ureteric legation, chronic urinary tract inflammation, and urinary tract neoplasm. 51 of 63 patients under went IVU, only in 28 of 51 patients IVU well detected their underlying pathology of hydronephrosis (55%), hydronephrosis well detected in other 23 cases by IVU without delineated the underlying pathology of it. In 33 cases of urinary tract stones IVU detected the underlying pathology in 25 cases (76%) and failed in other 8 cases ,in 5 cases of urinary tract masses IVU detected 1 case of 5 (20%) and failed in other 4 cases and also IVU detected 2 cases of 5 cases of renal tumor (40%) and failed to detect other 4 cases .IVU completely failed to detect any of the flowing underlying pathology ,ureteric stricture ,vesico ureteric diverticulum ,urinary tract neoplasm, and distal ureter legation. Helical CT scan has become a superior modality for diagnosing urinary tract abnormalities; because of high imaging resolution and rapid examination time. The study results show that, CT urography displayed extremely high accuracy in diagnosing underlying pathology of hydronephrosis (sensitivity 100%, specifity 100%), and overall CT diagnosed 93.7% of cases of this study ,(Reznek RH, et al 2005) resulted to CT diagnosed (53%) of his cases which is differ from this study result(93.7%) and that may be due to few number of his 15 patients, other study by (7).CT diagnosed (19%) and non diagnosed 12 out of 137(9%) in cases of hydronephrosis, which is near to this result. Because most stones radiopaque on CT scan, non-enhanced CT urography is sufficient in diagnosing stones without IV contrast medium administration. According to 1recent study by (9).non contrast CT demonstrated superior sensitivity to IVU in detecting renal tract calculi and this study reached to same results. By using non-enhanced CT urography as the diagnostic modality for patients with clinical suspicion of urolithiasis, the unwarranted side effect due to IV contrast medium during IVU could also be prevented. Furthermore, it is also beneficial in improving the diagnostic rate of urolithiasis when analyzing radiograph in conjunction with CT scan and CT urography (2).Although almost all renal stones are radiopaque on CT scan, in extremely rare conditions they are radiolucent due to variable component of renal stones. In one case radiolucency of the renal stone with only mild marginal calcification was noted in the renal pelvis, which was mimic the renal pelvis tumor, CT detected all stones cases in this study, in other studies, M patlas result in 43 stones cases CT detected (93%), and Douglas Hshefro in 23 stone cases CT detected 22(96%).Some stones cannot be detected by CT, example of this stones composed of HIV protease inhibitors and one type of gallbladder stone which can be detected well by the ultrasound. Other studies also reported that phleboliths might mimic renal stones at the pelvic region, especially in children who lack adipose tissue at the pelvis cavity, which may cause diagnostic pitfalls. 3D reformatted CT urography can provide more information in distinguishing phleboliths from renal stones than U/S, by viewing the anatomic relationship with Multiplanar images. CT urography also has good potential for diagnosing of masses with clinical manifestation of hydronephrosis, CT urography correctly detected 7 out of 7 patients with different site abdominal masses which compressed the urinary tract and caused hydronephrosis. Although almost all renal stones are radiopaque on CT scan, in extremely rare conditions, they are radiolucent due to variable component of renal stones. In just 1 case, radiolucency of the renal stone with only mild marginal calcification was noted in the renal pelvis, which was mimic the renal pelvis tumor, CT detected all stones cases in this study. In other studies, M patlas result in 43 stones cases CT detected 39 (93%), and Douglas Hshefro in 23 stones cases CT detected 22 (96%), and in this study CT detected (100%) of cases of stones. some stones cannot be detected by CT, for example stones composed of (HIV) protean inhibitors and one type of gallbladder stone which can be detected well by ultrasound. In 63 patients with clinical manifestation of hydronephrosis, CT urography correctly detected 7 out of 7 patients with different side abdominal masses which compressed the urinary tract. and caused hydronephrosis, one psoas muscle mass ,one elongated para spinal mass.2 renal pelvic mass 3 bladder masses, to my knowledge CT urography has superior sensitivity in detecting neoplasm in the urinary system than IVU do. Especially in patients with impaired renal function so that the urinary system couldn't be opacified on IVU. CT urography is also better in demonstrating the extent of tumor involvement than U/S and IVU. however, CT urography is limited in detecting early neoplasm arising from the urothalial epithelium,which can be better demonstrated on uretroscopy, just as in 1 patient, who had early superficial epithelial cell carcinoma of the ureter and was miss interrupted as negative findings on CT urography. CT also detected 5 out of 5 urinary tract tumors. Including (3 cases of renal tumor, 2 cases of bladder tumor). The study found that CT urography was effective to diagnosing these urinary tract tumors, the same conclusion was also made by another study(Semen Roentgen. 2001), CT urography also provides more information than IVU in determining the nature of urinary tract stones,[10] and this study also supports this point,41 out of 41 patients were correctly diagnosed as urinary tract stones, by CT urography,which was provide by other investigation, chronic inflammatory process of urinary tract may have confusing imaging findings that are indistinct from malignancy, we suggest follow up of the patient clinical course and histopathological correlation are necessary. In conclusion, CT urography is a newly developed modality for evaluation underlying pathology of hydronephrosis. The preliminary results show CT urography is exceptional in diagnosing underlying pathology of hydronephrosis .it also can provide more information on the urinary tract abnormality of the patients. Considering the diagnostic value and immediate proper management for patients of urinary tract disorders, CT urography is superior examination and should be and alternative or substitute modality for IVU.

CONCLUSION

CTU is the best modality for demonstration of underlying pathology of hydronephrosis. It is better in showing radiolucent stones and non-opacified urinary system. CTU demonstrate more soft tissues information than IVU and U/S in the patients with urinary tract tumors. CT may be an alternative modality for children with deterioration of renal function or allergic history of contrast medium. Many different imaging modalities have been used in the evaluation of patients with hydronephrosis and patients frequently require multiple examinations for work-up. In addition, the combination of unenhanced and enhanced imaging provides outstanding evaluation of renal masses. Findings at excretory-phase imaging mimic IVU findings and allow excellent evaluation of the

collection systems and ureters. Bladder diseases, a common cause of hydronephrosis, are often well seen on unenhanced or excretory-phase images, although cystoscopy may still be necessary. Although more experience and data are necessary, CT protocol has the potential to provide accurate evaluation of patients with hydronephrosis with a single comprehensive CT examination.

REFERENCES

1. Katz DS, Lane, Sommer. Unenhanced Helical CT of Ureteral Stones 1996;166:1319.
2. Niall O, Russell j, Macgregor r, Duncan h, mullins j Comparison of Noncontrast CT with Excretory Urography in Assessment of Acute Flank Pain.1999; 161,534-7.
3. Louis, Mosby .Medical Imaging Physics,. 1992.
4. Invest Radiol.Guidelines for Urography in a Cost-sensitive Environment.1990;28:13-19.
6. Langer JE.Computed Tomography and Ultrasonography of Acute Renal Abnormalities 2001;2:99-107.
7. Nemoy , Fichman.Unilateral Ureteral Obstruction 1973;225:512-513
8. Chris Ball and Clare Wotton.Acute Renal Failure. April 2000.
9. Reznek RH.Ultrasound and Computed Tomography in Patient with Impaired Renal Function. April 2005.
10. Viewing J.Unenhanced Computerized Tomography in Evaluation of Acute Flank pain. 1998.
11. Dietl J, Wien med Wochenschr.Strangulation of Floating Kidneys (in german), 1864;14:153-166,